Soil Report Update April 2020 prepared by Brien Park

This update to the report issued on (04/16/2020) restructures and clarifies the expected impacts to ashy soils, steep slopes, and effects from temp roads and project design criteria to improve readability and facilitate better comparison between alternatives. No changes in overall conclusions of effects were made.

3.2.6.1 Affected Environment

The Upper Touchet Project area is near the northern edge of the Blue Mountains, which is composed of a series of smaller ranges, canyons, and hilly plateaus that trend northeast to southwest. Evident on the landscape are the relatively flat lying Columbia River Basalts that eroded over time, forming broad plateaus to subsequently smaller plateaus and into current generally steep sided, branched canyons ranging from 100 to 1700 feet deep. Mountain backslopes range between 15 and greater than 75 percent slope. Igneous basalts weather into gravelly and cobbly deposits that are mantled by volcanic ash deposits. Soils vary in their response to logging, based on such factors as the presence and thickness of a volcanic ash in the soil profile, soil thickness to a lithic contact, and slope steepness. Web Soil Survey is the source for soil maps, soil series, and soil properties used in this analysis and includes information specific to the Umatilla National Forest (USDA-NRCS, Soil Survey Division, 2018). The soil survey is used to understand soil properties and characteristics of soils in the project area. Soils range in thickness with landscape position, aspect, and slope.

Acres of varying soil depth are estimated using soil survey information from Web Soil Survey. Acre estimates of soil thickness are based on percentages of major and minor components of very shallow (less than 10 inches) and shallow soil (10 to 20 inches) where criteria are met for more than 50 percent of the soil map unit area. Based on this analysis there are 84 acres or almost 2 percent of the total project area with very shallow soil, 496 acres or 11 percent of the total area with shallow soil, and 3,873 acres or 87 percent of the total area with soils greater than 20 inches deep. Varying soil depths are present in most soil map units making it difficult to identify absolute areas to avoid however recommendations are provided to deciding officials and discussed in this document to some extent.

Over 70 percent of the project activity unit area has ashy soils in the upper profile horizons (Table 1) (USDA-NRCS, Soil Survey Division, 2018). Approximately 8 percent of the area is identified as shallow soil (lithic). The remaining soil have mixed fine and coarse material (loamy-skeletal).

Table 1. Classification of soils within Activity Units

Major Soil Component	Soil Classification	% of Activity Unit Area with Series Classification
Troutmeadows, Mountemily	Ashy over loamy-skeletal amorphic over isotic typic Vitricryands	26%
Syrupcreek, Limberjim, Tamara	Ashy over loamy-skeletal, amorphic over isotic, frigid Alfic Udivitrands	45%
Harl	Ahy-skeletal over loamy-skeletal, amorphic over isotic, frigid Typic Udivitrands	1%
Crawfish, Burgerbutte	Loamy-skeletal, isotic Lithic Humicryepts	3%
Larabee, Klicker, Klickson, Getaway	Loamy-skeletal, isotic, frigid Vitrandic Argixerolls	20%
Anatone, Bocker	Loamy-skeletal, mixed, superactive, frigid Lithic Haploxerolls	5%

Ash horizons in the project area source from the eruption of MT Mazama from about 7000 years ago. Ashy soils have low bulk density and higher infiltration rates with high-water holding capacity resulting in lower surface runoff and greater soil productivity compared to clayey soils. Ashy soils lacking rock fragments have low bearing strength which makes them more susceptible to compaction and displacement. When soils are compacted the hydrologic function of the soil is negatively affected as pore space is compressed lowering infiltration rates

causing a droughty soil. Soil compaction results in lower soil productivity which can change vegetation densities or species composition in the compressed area.

Ash horizons in the project area range in thickness from 4 to 10 inches thick on shallow soils and can be as thick as 14 to 30 inches on moderately deep and deep soils. Ashy soil profiles range from clean ash deposits over higher clay content horizons with abundant rock fragments to mixed ashy and rock fragment horizons. Rock fragment content in ashy horizons near the surface lessens the susceptibility of compaction. When non-mixed ashy soils are disturbed, erosion is greater due to fine particle size and lack of particle cohesiveness. Restoration efforts such as sub-soiling is effective in ashy soils when rock fragment content is low in upper horizons due to the lack of equipment obstacles.

The following table expresses relative susceptibility to compaction, displacement, and erosion based on soil depth, soil texture, and slope (Table 2). The forest soil survey (USDA-NRCS, Soil Survey Division, 2018) identifies differences in ratings for ground-based and skyline harvest equipment suitability with respect to slope where areas sloping less than 15 percent are rate low, 15 to 35 percent are moderate and greater than 35 percent high(greater discussion of soil interpretations for the project area is located in Resource Indicators and Measures section). This information is used in the formulation of Table 2.

Table 2. Susceptibility of Detrimental Soil Conditions with Soil Depth and Texture.

		ashy low slope	mixed low slope	ashy steep slope	mixed steep slope
Compaction					
	0-10 inches	high	moderate	high	moderate
	10-20 inches	moderate	moderate	high	moderate
	20+ inches	moderate	low	moderate	moderate
Displacement					
	0-10 inches	high	low	high	moderate
	10-20 inches	high	moderate	high	moderate
	20+ inches	moderate	moderate	high	moderate
Erosion					
	0-10 inches	moderate	low	high	low
	10-20 inches	moderate	low	high	moderate
	20+ inches	moderate	low	high	moderate

Past and present activities in the project area include harvest, prescribed burning and planting as well as the creation of the Ski Bluewood developed area, and road construction. In 2006 Columbia Complex Fire burned on National Forest Service lands. Variability in the burn produced areas of high soil burn severity. Weather patterns after the burn did not result in erosive run off events. In the fall of 2018, a prescribed landscape burn occurred the in the northern most area of the project.

Resource Indicators and Measures

Alternatives were evaluated based on their effect to soil productivity indicated by soil compaction, soil displacement, and nutrient cycling (Table 3).

Table 3. Resource indicators and measures for assessing effects

Issue	Resource Indicator	Measure	Source

Soil Productivity	Soil Compaction	New Roads, Skid Trails, Landings	LRMP, FSM, Mulit-Use Sustainable Yield Act, R6 Supplement
Soil Productivity	Soil Displacement	Exposed soil sub-horizons, Puddling, Rutting, and Erosion	LRMP, FSM, Mulit-Use Sustainable Yield Act, R6 Supplement
Soil Productivity	Nutrient Cycling	Woody Material Cover Per Acre	LRMP, FSM, Mulit-Use Sustainable Yield Act, R6 Supplement

Soil Compaction

Measures: skid trails, skyline corridors, transportation corridors.

NRCS interpretations of soil data indicate that most of the area has a 'high' compaction potential when soils are moist (refer to custom soil report included with soils file). Ratings are based on properties of the upper 12 inches of the soil profile because most soil compaction by ground-based and skyline activities occurs within the upper 12 inches. Soil factors included in the analysis are texture, structure, and rock fragment content. The rating is most influenced by the presence of ashy soil horizons which are silty or very fine sandy loam. Ratings are reduced with increasing rock fragments in the upper horizons and can similarly be reduced with the addition of 6 inches or more of slash on the landscape.

Past harvest activities resulted in compacted soils and associated decreased hydrologic function. Vehicles traversing units to cut and transport timber out of the unit added to soil compaction. Skidding, skyline corridors, and transportation corridors are still visible on the landscape to some degree. Skyline or cable logging added compaction along the skyline corridors as trees are suspended and dragged out of units. Based on a review of representative project area units, compaction by previous activities have left detrimental soil conditions for 8 to 15 percent of the project area. Most of the current detrimental soil conditions present in the project area are compaction which is viewable as platy soil structure in the upper 10 to 18 inches of soil profiles. Compaction persists longest on the landscape because it requires years of wetting-drying cycles, freeze-thaw cycles, and root growth to reform the subangular soil structure typical of undisturbed areas. Adjacent forests reviewed harvest activity effects 20 and more years after the activities were completed for several projects and found that detrimental soil conditions comprised 10 to 17 percent of project areas. Increased time since harvest activities found less soil compaction. Due to similarities in parent material, landscape morphology, presence of ashy soils, similar climate, and similar plant associations their findings can be applied to estimated detrimental soil conditions and recovery times for Umatilla National Forest soils.

Soil restoration attempt have varying success rates which are usually associated with soil depth. Deeper soils are easier to restore after compaction due to their thickness. Sub-soiling or ripping of deep soils after compaction of the upper 18 to 24 initiates the restoration of soil structure and hydrologic function. Soils that are less than 20 inches are more difficult to restore due to depth and equipment limitations. Ripping compacted shallow soil aids in restoring some hydrologic function but due to the quantity of rock fragments in most shallow soil restoring soil function is difficult to accomplish without disrupting the entire profile. Very shallow soils (less than 10 inches deep) are the most difficult to restore due to soil depth and rock fragments quantity in the profile. Most soil structure in very shallow soils occurs between rock fragments. When rock fragments and soil are compacted then ripped the entire profile is mixed usually sifting the finer material towards the bottom of the profile. This results in a more droughty profile than previously existed. Avoiding ground-based activities on very shallow soils is critical. Deeper soils can be restored to original function within 30 to 60 years compared to hundreds of years for very shallow soils.

Every mile of new road placement adds a mile of soil compaction. The characteristics that make a soil profile function are opposite for a proper functioning road. Existing roads are not included in assessment of soil

compaction to the project area. Refer to Transportation Systems section for more information on proposed road use. Only new road placement and existing road removal is considered in this analysis.

Ground-based activities result in soil compaction on all soil depths. The magnitude of soil compaction varies with activity type, soil depth, soil texture, and presence or absence of rock fragments in the upper soil profile. Most soil compaction occurs within the upper 12 to 18 inches of the profile. When present, rock fragments in the upper profile provide stability and decreasing the thickness of soil compaction in the profile. Where rock fragments content is over 35 percent and compaction occur, it may be harder to restore by subsoiling and ripping by a backhoe may be the only option. Soil thickness relative to the depth of soil compaction due to different ground activities determines severity of the detrimental soil condition. The thickness of shallow soils (10 to 20 inches deep) makes them highly susceptible to soil compaction due to the volume of the profile affected by compaction. Ripping may be the only way to start to restore shallow soil structure and hydrologic function when sub-soiling is prohibitive.

Soil Displacement

Measures: exposed soil sub-horizons, puddling, rutting, and erosion.

Soil displacement exposes sub-horizons, which are less productive and require time and horizon development to return to natural productivity. A review of representative activity units finds minimal soil displacement still present adjacent to old skid trails, harvest corridors, landings and temporary roads. Areas where displacement occurred have stabilized with grass and forb growth and soil productivity of those areas is functioning. As a result, detrimental soil conditions from past soil displacement is no longer significantly adding to the current overall detrimental soil condition of the project area.

Project area soils have a 'medium' displacement rating when soils are dry and moist (refer to custom soil report included with soils file). A 'medium' rating indicates that the soils can be displaced by equipment operations but are moderate in their resistance to movement. Ratings are based on properties of the upper 12 inches of the soil profile. Soil factors included in the analysis are texture, rock fragment content, and thickness of surface layers with at least one percent organic matter. Ratings can be reduced by one class if 6 inches of organic matter or slash cover ground activity areas (refer to custom soil resource report). Areas of 'low' rating either have more than 6 inches of organic matter in the profile or are on shallow soil areas.

Puddling potential of soils in the project area is mostly medium with some high when soils are wet and above field capacity. Interpretation ratings are based on soil properties in the upper 12 inches of the profile.

Soil rutting may occur simultaneously with soil displacement and puddling. The project area is rated 'severe' for all areas except areas of shallow soils. 'Severe' rating indicates that ruts form easily. Ratings are based on depth to a water table, rock fragments on or below the surface, the Unified classification of the soil, depth to a restrictive layer, and slope.

Slope stability of ashy soils is a factor in determining potential for soil erodibility by different harvest activities. Slopes are steep on most mountain backslopes in the project area and erosion potential increases with increasing slope. Connectivity of disturbed areas is the greatest factor to erosion apart from the spatial extent of a specific disturbed area. When small areas of exposed sub-soil are connected to adjacent or down slope disturbed areas, the effects combine. When scattered over activity areas, organic matter cover (including woody debris) keeps disturbed areas from connecting and stops or slows surface flow from transporting soil away from the disturbed area or out of the activity unit. Areas of erosion from past ground activities have stabilized as seen by the areas supporting grass and forb growth. A review of representative units finds that past harvest activities resulting in soil erosion have stabilized. Evidence of eroded area stabilization is the presence of vegetative growth in depression and on areas of soil accumulation. Soil productivity increases with time as horizons develop in the disturbed areas.

The existing road system will be used for hauling out of the project area. Road maintenance is identified for 40 miles of system road and include blading, ditch relief culvert cleanout, spot rock, and ditch clean out as needed. Activities associated with current system roads are not considered to be additional to the project area as they are already part of existing condition. Roads in the project area all negatively affect soil productivity by soil displacement, compaction, potential erosion, and lack of organic matter no matter the road type. Many of the existing roads on mountain ridges or basalt flow tops traverse very shallow and shallow soil areas. These areas are visually desirable for expanding or adding landings or turn around areas but are the most susceptible soils to compaction. New road construction will be considered part of project activities adding to detrimental soil conditions

Using landslide ratings for Oregon areas of the forest and applying the same criteria for Upper Touchet project area, most of Upper Touchet has a 'moderate' to 'high' rating. Ratings are heavily weighted to slope with this analysis. 'High' ratings match to areas with slope greater than 35 percent and indicate areas with the greatest potential for mass wasting to occur under natural conditions. 'Moderate' ratings match slopes between 35 and 8 percent. The ratings associated with the Oregon landslide potential are estimates and do not consider deposit composition, vegetative cover, and mitigation associated with ground activities.

Nutrient cycling

Measures: surface cover of organic matter or woody material

Past harvest activities and fuel reduction efforts have resulted in a reduction of woody debris or fine organic matter. With time needle cast, twig fall, and grass and forb growth have added organic matter to the soil surface. As a result of the identified activities and later organic matter accumulation on the soil surface, it is estimated that one percent or less of each activity unit lacks minimal organic matter. Woody debris and organic matter litter scattered after activities and accumulated over time provides protection to exposed soil sub-horizons.

Prescribed burning affects soil productivity by consuming surface organic matter during burns. Pile burning after harvest activities leaves disconnected burn pile areas that lack woody debris cover. Removal of organic matter from the soil surface diminishes nutrient cycling and soil productivity in the upper horizons of the soil profile. Organic matter acts as a blanket for the soil keeping temperatures moderated and holds soil moisture in the profile longer. Removal of the organic matter blanket results in dryer soils with greater changes in soil temperature throughout the day and seasons. This affects vegetative growth and over time depletes soil productivity. Past activities and organic matter accumulations over time have resulted in adequate levels of fine and woody organic matter on the landscape surface. Maintaining as much organic matter cover while still meeting fuel reduction needs is important to future soil productivity.

Based on analysis of past projects and small-scale reports of adjacent forests along with visits to representative units it is estimated that detrimental soil conditions (compaction, displacement, erosion, and absence of organic matter cover) are found on between 5 and 15 percent for activity units in the project area. Soil compaction is the most persistent and makes up most of the detrimental soil conditions presently. Displacement, erosion, and lack of organic matter with time have all ameliorated enough since last harvest activities to be functioning properly. Following 'Soil Moisture vs. Texture Operability' document will positively affect the ratings for displacement, puddling, and rutting. Adding slash on ground activity areas also increases ratings because it disperses vehicle weight.

3.1.1.1 Relevant Laws, Regulations, Policies, Guidance, and Plans for Soils

Forest Service Manual 2520 Pacific Northwest Region (R6) supplement no. 2500.98-1 (USDA Forest Service, 1998), Umatilla Forest Land and Resource Management Plan (USDA Forest Service, 1990), National Best Management Practices for Water Quality Management on National Forest System Lands (USDA, Forest Service, FS-990a, 2012), and Umatilla National Forest Soil Survey, WA714 (USDA-NRCS, Soil Survey Division, 2018)

3.1.1.2 Methodology

Aerial photo, GIS analyses and review of existing Information was used in this analysis. Photos of this project area and other project areas with similar design criteria and soil-vegetative relationships were compared to detect potential areas of compaction and displacement, mass wasting, landform morphologies, and aspects in the project area. An assumption of 10 to 17 percent of the project area suffers from detrimental soil conditions resulting from past harvest activities. This assumption is based on visits to representative activity units, analysis of similar activities on adjacent forests where activities have stopped for 20 years or more. An assumption was made that detrimental soil conditions on slopes >35% would be approximately 1.5 times than on flatter ground. Analysis of soils in the project area use Web Soil Survey 'Suitability and Limitation Ratings' from the Umatilla Forest soil survey (USDA, NRCS, Soil Survey Division, 2018).

Scale of analysis

Productivity of soil is place specific and does not move resulting in the spatial bounding effect for analysis is Upper Touchet project area boundary. Compaction and soil displacement are not transitory from the project area which limits the spatial extent to which these detrimental soil conditions effect landscape. Presence or absence of woody material on the landscape is limited to the immediate area for soil nutrient cycling. Soil moved by surficial water flow can transport outside of the identified project, but the area of decreasing soil productivity does not move with erosion. Woody material on the landscape limits the extent of transported soil and sediment up to the next piece of woody material. Soil productivity is negatively affected during and immediately after project activities occur on the landscape. Once activities stop (harvesting, skidding, and driving) soil processes start to act on compaction, displacement, and erosional areas. Soils start to reform or decompress with the first significant moisture addition (rain or snowmelt). Soil productivity continues to improve with time, moisture cycles, and freeze thaw cycles. Temporal boundaries for cumulative effects include activities that occurred over 40 years ago and consider activities 40 years into the future. Activities to include in cumulative effects are all ground-based harvest, cable harvest, and pile burning actions.

Due to the length of time soils needed for recovery after detrimental soil disturbance adjacent projects are considered as part of the cumulative effects. Past projects following the forest plan and recommended PDCs result in current detrimental soil conditions below 20%. Current and future activities will result in less than 20 percent detrimental soil conditions for the project area as required by Forest Plan.

3.1.1.3 Impact Analysis

ALTERNATIVE A

ANALYSES:

Direct and Indirect Effects

Ashy soils cover approximately 70 percent of identified project activity units. Soil compaction to some degree is associated with all forms of ground-based harvest activities. Areas of shallow soil are most susceptible to compaction. Ground activity units, skyline and ground-based, are analyzed for potential soil compaction based on the percentage of unit activity are overlapping very shallow and shallow soil area. Eleven of 180 total acres, or 6 percent, of ground-based activity in alternative A overlap very shallow and shallow soils. Alternative A has 52.5 of 800 total acres, or 6 percent, of skyline activity is identified for alternative A overlap with very shallow and shallow soils. Total acres of identified activities that result in soil compaction associated with alternative A is 63.5 acres or 6 percent (Table 4). The very shallow and shallow areas of harvest units are along a narrow edge.

Table 4. Activity Unit Acres for Alternative A That Overlap Very Shallow and Shallow Soil Areas.

Activity Unit	Activity	Total Acres	Very Shallow and Shallow Soil Acres
01C	Ground	37	7
04	Skyline	6.5	1.5

14	Skyline	19.8	3
17	Skyline	85.6	15
20	Skyline	26.5	10
23	Skyline	65.8	8
25	Skyline	76	10
28	Skyline	34	5
30	Ground	34	4
Total			**63.5 acres combined Ground and Skyline**

Skyline activities produce linear areas of soil compaction within skyline corridors in the direction of slope, which can act as a continuous conduit for surface flow and associated soil erosion. Soil compaction occurs as bundles are dragged along the soil surface with slope on their way out of the unit. With skyline logging the number of landings increases to accommodate vehicle staging areas, but the landings are generally smaller and dispersed throughout the project area. Additional landings associated with skyline logging add to soil compaction but during activity until equipment landings are scarified and seeded over when activities are done.

Greater soil compaction and displacement within corridors occurs when cables and logs are not maintained at proper angles. Soil erosion occurs when organic matter or woody debris is swept away from the suspension corridor during log removal, exposing subsoil. Optimal slope for skyline logging is greater than 35% to prevent soil displacement and most alternative A skyline units meet this criterion. Additional landings associated with skyline logging usually result in soil displacement, but during the activity until equipment landings are scarified and seeded after completion of the project.

Helicopter logging activities minimize soil compaction by tracked and wheeled equipment in ashy soils. Helicopter logging is identified for activity units with dominantly slopes greater than 35 percent. In alternative A about half of the helicopter activity units are in areas not accessible by ground methods, skyline or ground based. There are 170 helicopter acres identified in alternative A. Helicopter unit 05 overlaps with shallow soils along on 2 acres of the unit's edge. Ground disturbance by tree fall and rolling or sliding down slope may result in limited and very localized soil compaction and displacement. Compaction is minimal and only occurs where trees fall or are moved to for bundling. Soil compaction and displacement is unlikely to occur to any significant extent with helicopter harvesting.

Mastication activities add to soil compaction and minor amounts of soil displacement as vehicles traverse the landscape. Most areas treated by mastication would be more disturbed if sub-soiling follows to start restoration of soil structure and hydrologic function and for this reason low ground pressure vehicles and following existing disturbed areas is preferable (PDC soil 5, 6, 10, and 17).

The greatest amount of soil displacement of ashy soil occurs when ground-based activities are performed when soils are wet. Following PDC soil 17 and Soil Moisture vs Texture Operability guide will stop activities when soil displacement and compaction would occur with highest effect, reducing the overall impact of activities despite the ashy character of the soil. Soil compaction resulting from vehicle activity in corridors should be restored after harvest activities with the use of a sub-soil device or ripping the top 18 to 24 inches of the compacted surface (PDC soil 1 and 16).

Ground equipment focuses tracks and tires energy to maintain friction on a steeper slope. When slope increases, the potential for that energy to displace soil increases. Following PDC soil 7 will reduce impact because operating equipment on slash minimizes soil displacement on all slopes by dispersing the focused energy, allowing the vehicle to maintain friction without digging into the soil profile. Ground based activity units 01B, 02, 11, and 28A contain some limited area with a slope greater than 35 percent. Table 5 presents activity units and the acres that

are on steep slopes. A little more than half of all the steep slope acres (greater than 35 percent) identified for ground-based activities are ashy and lack rock fragments in the upper 10 to 14 inches of the soil profile (soil map units 4941CD, 5019CO, and 5723BO) which limits ground activities in these areas. Approximately 34 of 180 acres, or 19 percent, of ground-based activity units occur on steep slopes. Avoiding ground-based activities or dropping these areas will reduce the impact within ground-based units. Some variability exists between GIS estimates and actual landscape slope so estimates may differ by 5 percent. The steep slopes in helicopter activity units make sub-soil exposure most important to avoid, but surface organic matter is not generally removed with helicopter activities and the effects are negligible.

Table 5. Activity Unit Acres in Alternative B That Overlap Steep Slopes (greater than 35% slope).

Activity Unit	Activity	Unit Acres	Steep Slope Acres
01A	Ground	39	10
01C	Ground	37	8
29	Ground	11	9
30	Ground	34.5	7
Total			**34 Steep Slope Acres**

Skyline units 20 and 26 have large areas with slopes less than 35 percent, making them more susceptible to soil displacement from possible inappropriate cable angle as timber bundles are dragged across the landscape.

Most of the roads in the project area are existing. Many in the existing project roads are located at mountain ridges or tops of basalt flows and traverse very shallow and shallow soils. The wide-open areas of very shallow and shallow soils are desirable for landing placement, turn around areas, or placement of new roads. Any additional disturbance in the very shallow and shallow areas adjacent to existing roads add acres of detrimental soil conditions into the future. Where roads exist soil damage already exists and will not be considered when assessing detrimental soil conditions associated with this project.

There are 1.3 miles of temporary road proposed for alternative A with 0.24 miles already existing on the Forest road template. This leaves 1.05 miles of new temporary roads or approximately 2 acres of new soil compaction and displacement proposed for alternative A. The new temporary roads are in small segments mostly located within or adjacent to skyline units. Approximately 0.43 miles of new temporary road is planned for shallow soil areas. Placement of the 0.43 miles will result in 0.8 acres of perpetual soil compaction into the foreseeable future. The remaining 0.57 miles of new temporary road can be obliterated with little effort to restore soil structure and hydrologic function. If the road is not obliterated it will also perpetually add to soil compaction percent of the project area. Decommissioning of new roads will start the restoration of soil structure and hydrologic function. Depending on the level of decommissioning, soil productivity effects remains until the road is completely obliterated and contoured to the landscape.

Effects of woody material to nutrient cycling are not immediately seen after activities but noticeable over years and tens of years. Decreased woody material in nutrient cycling is viewable on the landscape within 5 to 10 years and can take an estimated additional 5 to 10 years or more to ameliorate after the effects are noticed and efforts to restore are performed. Decreased soil productivity can result in lower shrub, forb, and grass production and ultimately diminished tree growth.

Removal of surficial organic matter within suspension corridors as a result of harvest actions also removes potential nutrients from the soil profile. Maintaining an organic matter surface layer (PDC soil 8) in activity units and on disturbed soils keeps soils from transporting out of the disturbed area and maintains nutrient cycling. Reuse of existing areas with detrimental soil conditions concentrate future activities on already impacted soils and do not add to detrimental soil conditions for the project area.

Where non-commercial thinning is the primary objective, the maintenance of long-term slope stability and soil

health is desired. The growth of leave trees will contribute toward long-term slope stability. Hand thinning activities do not add to detrimental soil conditions.

Landscape burning returns a vegetative mosaic where soil productivity benefits with increased root and organic litter additions on the soil surface. Intensity of landscape burning is variable. Areas of high soil burn severity associated with landscape burning are usually patchy and disjointed. Limited connectivity between disturbed soil areas keeps soil erosion low. Ash left after burning is incorporated in the upper soil profile with organism activity and adds to soil productivity. Pile burning creates intensely burned areas that leave most soils sterile or with low soil productivity. Following forest plan guidelines and PDCs (soil 2) aids in faster restoration of disturbed soil to normal hydrologic function and productivity by keeping the soil in place allowing for structure to reform. Scattering of woody material over burn pile areas protects soil from surficial erosion. Past harvest activities and fuel reduction efforts have resulted in a reduction of woody debris or fine organic matter. With time needle cast, twig fall, and grass and forb growth have added organic matter to the soil surface. As a result of the identified activities and later organic matter accumulation on the soil surface, it is estimated that one percent or less of each activity unit lacks minimal organic matter.

Additional landings associated with skyline logging are scarified after project completion and seeded. Woody material is scattered over the area to keep soil in place and to add nutrients back to the area.

Soil erosion occurs when subsurface horizons are exposed by the removal of organic matter from the landscape surface. Maintaining surface organic matter including woody debris holds soil in place. Woody debris also slows surface flow and allows for eroded soil to accumulate.

Indirect impacts of harvest activities occur by opening the tree canopy for increased understory growth include increased soil nutrient cycling, soil hydrologic function, and soil productivity by limiting changes in soil temperature. As understory increases, so does root turn over by grasses and forbs. Deciduous trees also increase and drop leaves yearly on the forest floor. The incorporation of dead roots and surficial litter into the upper horizons of the soil profile increases soil nutrients and hydrologic function. Decomposed organic matter acts as a sponge holding moisture. It also acts as a blanket to minimize the temperature of the upper soil profile. Decomposing organic matter also provides nutrients to establish grasses, forbs, shrubs, and trees. Increasing plant diversity by opening the forest canopy also increases the rate of soil recovery from soil compaction, displacement, and erosion. Exposing detrimental soil conditions to a variety of plant species allows for a variety of ways roots can break apart soil compaction and hold exposed sub-soil in place. Indirect effects to timber harvest are negligible to minor short term and can be positive in the long term when PDCs for varying specialties are followed.

CUMULATIVE IMPACTS ANALYSES:

The impacts of Alternative A plus the impacts of past grazing, firewood harvest, timber harvest, and recreation activities by Skyline Basin resort, present recreational activities by Ski Bluewood resort, and future recreational activities by Ski Bluewood resort have varying degrees of impact on the area. Grazing activities have been minimal to the impacts of soil productivity. Past harvest activities in the 1980's and 1990's have contributed soil compaction, soil displacement, and soil erosion. With time detrimental soil conditions from harvest activities have ameliorated to the current 8 to 15% of the proposed project area. Recreation activities have impacted the project area the most but have been limited to the footprint of the ski resort. Recreational activities including winter sports and maintenance activities persist and will likely continue into the foreseeable future to the same degree as before with negligible cumulative effect. Firewood cutting and all-terrain vehicle use would continue to impact a negligible amount of soil in harvest units, as recovery from past use balances impacts from future use.

Effects of past ground disturbing harvest activities (ground-based and skyline systems) were analyzed to determine the overall effect on soil productivity. The most persistent detrimental soil condition due to vehicle activity, skidding, and log suspension activities is soil compaction. Soil displacement from past activities is still visible but the effects of soil displacement on soil productivity is significantly less and less persistent than soil compaction.

The same is seen with areas of soil erosion associated with soil compaction and displacement. Past harvest activities followed project design elements (PDCs) which limited the effects of ground activities and aided in restoring soil function and productivity. Increased grass and herb growth in these areas support the conclusion of improved soil structure and hydrologic function. Effects of soil compaction and displacement are immediate with a high intensity and will persist on the landscape for up to 20 years or more (Giest, 1989). However, once activities have stopped soil forming factors start to act on the compacted soil to improve soil structure and return hydrologic function.

Cumulative effects of soil productivity are analyzed for the short term, a year to ten years, and for long term over ten years. These scales reflect the time needed for soil stabilization and for normal soil function to resume after disturbance activities. Effects of soil disturbance, compaction, displacement, and puddling are seen in soil productivity immediately after activities. Soil erosion may not be immediately noticed until the first significant rainstorm after activities. The length of time for soil erosion is dependent on severity of disturbance, connectivity of disturbance, and amount of slash or woody material present on the landscape after activities. More woody material shortens the duration of soil erosion.

Soil compaction and displacement on very shallow and shallow soil areas with high rock content is still visible on the landscape. Minimizing or avoiding disturbance to very shallow and shallow soils (PDC soil 1 and 13) is key to maintaining minimal future impacts to the area. Once very shallow and shallow soils are disturbed, the negative impacts persist longer in the future than on deeper more resilient soils even with mitigation measures. Avoidance or dropping areas with high acres of very shallow and shallow soil will result in 5 percent less potential for soil compaction and displacement by skyline and ground-based activities for this alternative. Avoidance of very shallow and shallow soils in activity units that do not comprise large acre areas is acceptable and can be easily done by following 'Lithic Soils and Managing Operations Guide'.

The 0.43 miles of new road on very shallow and shallow soils will add less than 1 acre to the overall detrimental soil conditions for the project. This is negligible and will not cause alternative A to exceed 20 percent detrimental soil conditions. Activities resulting in soil compaction and displacement have a negligible effect on soil productivity when PDCs are used keeping detrimental soil conditions below 10 to 17 percent which is just less than 20 percent that the Forest plan requires.

Implementation of PDCs is key to maintaining soil productivity or restoring productivity after ground activities are completed. Due to the low bulk density of ashy soils subsoiling or similar activities (PDC soil 1 and 16) were used to break up compacted horizons and speed up soil structure formation and soil hydrologic function. Slash or organic matter (PDC soil 8) was scattered on skid trails, in skyline corridors, and over landings to disrupt surficial flow and soil erosion. This will protect soils despite their ashy composition.

Helicopter activities are the least disturbing to soils when compared to ground-based and skyline activities by about 90 percent. There are no vehicles traversing activity units, logs are not dragged with slope, additional landings are not needed, and logs are removed with the least disturbance to soils. Due to the minimal disturbance of helicopter activities, no PDCs are directly targeted to this activity.

Over time, there has been less road construction, and new entries have required construction or reconstruction with design elements and mitigation measures to minimize soil displacement. Newer standards for road maintenance will ensure negligible to minor future impacts.

Skyline activities have a greatly reduced footprint on activity unit detrimental soil conditions when compared to ground-based activities. Falling of trees towards the skyline corridor minimizes disturbance as timber is bunched and dragged from the activity unit. Application of slash in skyline corridors slowed surface flow and prevented or limited soil erosion. The number of landings associated with skyline activities is greater because of the need for equipment landings but are generally small and are more dispersed and less connected. Landings are scarified or subsoiled and seeded after use. Also, slash is scattered over the area aiding in the restoration of compacted and displaced soils. These factors make skyline activities about a third less detrimental to soils when comparing the differences of activity intensity and disturbed area to ground-based activities.

Alternative A has approximately 47 acres of ground activities planned for very shallow and shallow soils which is 4 percent of the entire project area. Most of the areas with shallow slopes can be avoided by following the 'Lithic Soils and Managing Operations Guide' included in the soil folder. Ground activities on steep slopes have been identified for 34 acres, or 3 percent of the total project area. This suggests that only a minimal amount of ground-based activity areas exceed normal activity parameters requiring a soil scientist or hydrologist review for activities to occur.

Slope instability within the proposed thinning units is not anticipated if unstable areas, identified by pistole butting of tree trunks and rotated soil or slumped areas, are avoided and if PDCs (4,5,7,9, and 17) for activities are followed on all slopes. Potential adverse off-site (indirect) effects from treatment activities are not anticipated, and the potential for adverse cumulative effect is low. Consequently, potential slope instability with the proposed management in any unit is not considered a concern, with the design criteria mentioned previously. By following PDCs (soil 9) ground-based activities on steep slopes should be kept to a minimum unless cleared by a soil scientist or hydrologist forest plan (Appendix E, page E-28, Mechanical Mitigation Measures).

With the retention of adequate woody debris, potential adverse impacts to long-term soil productivity through nutrient loss, are not anticipated for any unit. The adverse cumulative impacts of the proposed action to soil nutrient cycling are anticipated to be negligible, and the beneficial impacts of woody debris minor to moderate. Since ashy soils cover most of the project area measures are needed to minimize displacement, compaction, and erosion and PDC SOIL-7 recommends slash to displace vehicle pressure to minimize soil displacement and depth of soil compaction in the profile. Slash will also disrupt exposed soil areas shortening erosion pathways. The contribution of woody debris of less than 2-3 inches in any one area from the proposed activities is expected to maintain minimal nutrient inputs for the foreseeable future. It is possible to improve soil productivity across all soil series by scattering and leaving a thin (2 to 4 inch) layer of slash, masticated mulch, or woody debris across all units. Benefits from these actions can be seen in the short term within 5 years of unit treatments. Soil erosion and woody material or surficial organic matter detrimental effects from past activities have ameliorated.

A noticeable increase in soil productivity is observable after activities have stopped within 6 months to a year as indicated by increasing grass and forb density. No adverse long- or short-term cumulative effects to soil nutrient loss are anticipated from this alternative. With application of the design elements and mitigation measures, along with these precautions, the adverse impacts to soil compaction will be minor in the short and long term and the beneficial positive impacts to soil compaction will be long term and moderate.

CONCLUSION:

Implementation of alternative A will not cause additional, measurable changes to direct, indirect or accumulative effects of soil productivity as required by Forest Plan and Region 6 Supplement. Based on analysis, very few acres of ground activities will occur outside of desired activity parameters in this alternative (Tables 4 and 5). Project design criteria (Appendix D) will minimize the magnitude of impact and the overall impacts for all activities within Alternative A for soil compaction, soil displacement, and nutrient cycling. Soil displacement due to harvest activities in units with steep slopes would be limited to short pitches or single passes (PDC soil 9). Skyline areas would maintain the greatest soil compaction but due to the intensity, or depth of compaction, the effects would be less than ground-based activities on steep slopes. Approximately 2 acres of detrimental soil conditions will be added to the project by the addition of 1.3 temporary roads. The additional two acres may be short lived if the new roads are obliterated after use. Avoiding very shallow soils within activity units can be achieved during administration of the sale by following the 'Lithic Soil and Managing Operations Guide' provided to sale administrators and shared with purchasers. Units most susceptible to detrimental soil disturbance due to the abundance of shallow soils include portions of ground-based units 01C and 30 along with skyline units 04, 14, 17, 20, 23, 25, and 28 (Table 4). Extreme care is needed if harvest activities are to be performed on these units. More important to avoid are the activity units with very shallow soils. Therefore, soil compaction and displacement would stay less than 20% keeping soil productivity high in unit areas. Overall impacts by ground-based activities are negligible to minor short term adverse direct impacts occurring on the project site when recommendations and PDCs are followed.

The adverse impacts of this project on slope instability are negligible in the long term and the beneficial impacts will benefit the slopes for decades to hundreds of years into the future. Application of PDCs to the project area aids in the restoration of soil productivity by disrupting the detrimental conditions associated with harvest activities. Subsoiling in soils of moderately deep, deep, and very deep depths aids in the hydrologic function of soils while soil structure ameliorates.

ALTERNATIVE B

ANALYSES:

Direct and Indirect Effects

Alternative B is the middle alternative for the number of ground-based acres identified. Alternative B has the same analysis as alternative A where unit polygons and identified activities overlap. Differences in unit activities between alternatives can be seen in table 10. The same activities that produce soil compaction in alternative A result in compaction in alternative B. There is no change in ashy soil distribution. Slopes for activity units do not change but the activity in the unit changes for some polygons.

Ground activity units are analyzed for potential soil compaction based on the percentage of unit activity are overlapping very shallow and shallow soil areas (Table 6). Eleven acres of 200 total acres of ground-based activity in alternative B overlap very shallow and shallow soils. Alternative B has 52.5 acres of 560 total acres, or 9 percent, of skyline activity overlap with very shallow and shallow soils alternative B. There are the same number of ground-based acres that overlap very shallow and shallow soils in alternative B, 11 acres, as alternative A. The percent of very shallow and shallow soil overlap out of the total acres for ground-based activity is 7 percent. The total percent of ground activities that potentially lead to soil compaction or displacement for alternative B is 8 percent.

Table 6. Activity Unit Acres for Alternative B That Overlap Very Shallow and Shallow Soil Areas.

Activity Unit	**Activity**	**Total Acres**	**Very Shallow and Shallow Soil Acres**
01C	Ground	37	7
04	Skyline	6.5	1.5
14	Skyline	10.5	3
17	Skyline	85.6	15
20	Skyline	26.5	10
23	Skyline	65.8	8
25	Skyline	76	10
28	Skyline	34	5
30	Ground	34	4
Total			**63.5 acres combined Ground and Skyline**

Alternative B has the least amount of skyline activities identified. Soil displacement and compaction by skyline logging will be less in alternative B, by about 20%, compared to alternative A and D.

There are 390 acres of helicopter activity in alternative B which is 220 more than alternative A and 315 more than alternative B. All helicopter units in alternative A are repeated in alternative B with the same analysis and potential for detrimental soil conditions (Table 13). Alternative B has 196 acres of helicopter activity that was identified as skyline activity in alternative A. Slopes for these units are dominantly greater than 35 percent but the difference in their designation from the helicopter units in alternative A (which are also included in this

alternative) is that vehicle access is possible by existing roads or new temporary roads for skyline equipment landings. Twenty-four acres, units 14 and 26A, of the helicopter activity are new to alternative B. Unit 14 is dominated by slopes greater than 35 percent. Unit 26 has about half the area with steep slopes.

Alternative B has the most helicopter acres identified for any alternative. A total of 34 percent of alternative B is helicopter activity compared to 15 percent in alternative A. This is 19 percent less soil compaction and displacement potential by skyline activities. Helicopter units 14A and 26A are not present in alternatives A or D but still have the same analysis due to similar soil development and slope. Due to the minimal disturbance of helicopter activities no PDCs are directly targeted to this activity.

Alternative B has the same analysis as alternative A where unit polygons and identified activities overlap. Differences in unit activities between alternatives can be seen in table 10. The same activities that produce soil displacement in alternative A result in displacement in alternative B. There is no change in ashy soil distribution. Slopes for activity units do not change but the activity in the unit changes for some polygons. Those activity units are addressed in this section.

Ground activity units are analyzed for potential soil displacement based on activity unit overlap with steep slopes in the project area (Table 7). Of the 200-total ground-based acres in Alternative B, approximately 41 acres, or 21 percent, occur on steep slopes. Soils on steep slopes in unit 20 are mostly ashy (5019CO) limiting activities that can be approved on those steeper slopes. A little more than half of all the steep slope soils in Alternative B are ashy and lack rock fragments in the upper 10 to 14 inches of the soil profile. Skyline unit 26 has a large area with slope less than 35 percent, which makes it more difficult to keep bundles at appropriate angles when moving off the unit.

Table 7. Activity Unit Acres in Alternative B That Overlap Steep Slopes (greater than 35% slope).

Activity Unit	**Activity**	**Unit Acres**	**Steep Slope Acres**
01A	Ground	39	10
01C	Ground	37	8
20	***Ground***	***26.5***	***7***
29	Ground	11	9
30	Ground	34.5	7
Total			**41 Steep Slope Acres**

Potential for soil compaction and displacement due to ground-based activities is 2% more than alternative A and about 5% less than alternative D when compared total activity acres. Utilizing existing compacted areas as much as possible will concentrate compaction on soils already impacted, and, where possible, existing compaction will be reduced through mechanical means (subsoiling). With these precautions, the negative impacts to soil compaction will be minor and the positive impacts to soil compaction will be moderate to major.

There is no proposed increase of road miles of any kind for alternative B.

Indirect impacts of harvest activities by opening the tree canopy for increased understory growth include increased soil nutrient cycling, soil hydrologic function, and soil productivity by limiting changes in soil temperature. As understory increases so does root turn over by grasses and forbs. Deciduous trees also increase and drop leaves yearly on the forest floor. The incorporation of dead roots and surficial litter into the upper horizons of the soil profile increases soil nutrients and hydrologic function. Decomposed organic matter acts as a sponge holding moisture. It also acts as a blanket to minimize the temperature of the upper soil profile. Decomposing organic matter also provides nutrients to establish grasses, forbs, shrubs, and trees. Increasing

plant diversity by opening the forest canopy also increases the rate of soil recovery from soil compaction, displacement, and erosion. Exposing detrimental soil conditions to a variety of plant species allows for a variety of ways roots can break apart soil compaction and hold exposed sub-soil in place. Indirect effects to timber harvest are negligible to minor short term and can be positive in the long term when PDCs for varying specialties are followed.

CUMULATIVE IMPACTS ANALYSES:

There are 560 acres of skyline activities in alternative B which is 240 acres less than alternative A and 270 acres less than alternative D. There are 390 acres identified for helicopter activity for alternative B which is 220 acres more than alternative A and 315 acres more than alternative D. There are 200 acres of ground-based activity in alternative B which 20 more than alternative A and 100 less than alternative D.
Direct and indirect impacts for alternative B are the same as alternative A with minor differences. There is 19 percent less soil compaction and displacement proposed by alternative B when compared to alternative A due to increases to helicopter activity. potential by skyline activities. There are no addition of temporary road miles proposed, so alternative B has 2 fewer acres of detrimental soil conditions when compared to alternative A.

CONCLUSION:

Alternative B has approximately 200 ground-based activity acres, 560 cable logging acres, and 390 helicopter acres. Alternative B proposes the least effect on soils due to the large number of identified helicopter units. Because alternative B overlaps alternative A most conclusions would be the same except for 195 fewer acres disturbed by ground activities (skyline and ground-based) in alternative B. Overall impacts are negligible to minor short-term adverse impacts directly on the project site. Indirect impacts the same as alternative A with the same severity. Based on analysis, few units will be treated with ground-based methods on slopes greater than 35% in this alternative.

ALTERNATIVE D

ANALYSES:

Alternative D has the most ground-based acres. Alternative has the same analysis as alternative A and B where unit polygons and identified activities overlap. Differences in unit activities between alternatives can be seen in table 10. The same activities that produce soil compaction in alternative A and B result in soil compaction and displacement in alternative D. There is no change in ashy soil distribution. Slopes for activity units do not change but the activity in the unit changes for some polygons.

Ground activity units are analyzed for potential soil compaction based on the percentage of unit activity are overlapping very shallow and shallow soil areas (Table 8). There are 34 of 300 acres, or 11 percent, of ground-based activity in alternative D that overlap very shallow and shallow soils. There are 49 of 830 acers, or 6 percent, of skyline acres that overlap very shallow and shallow soils. The total percent of ground activities that potentially lead to soil compaction or displacement for alternative D is 7 percent.

Table 8. Activity Unit Acres in Alternative D That Overlap Very Shallow and Shallow Soil Areas.

Activity Unit	Activity	Total Acres	Very Shallow and Shallow Soil Acres
01C	Ground	37	7
04	Skyline	6.5	3
14	Skyline	20	3
17	Skyline	90	15
20	Ground	27	10
23	Skyline	66	8

25	Skyline	76	6
30	Ground	42	8
40	Skyline	33	14
41	Ground	9	2
42	Ground	26	7
Total			**83 acres combined Ground and Skyline**

In alternative D approximately 83 of 300 acres, or 28 percent of ground-based activity unit acres occur on steep slopes. Units 33A, 34, and 34A have many short steep sloped pitches interspersed throughout. About three quarters of all the steep slope soils in alternative D are ashy and lack rock fragments in the upper 10 to 14 inches of the soil profile (soil map unit number 5727CO and 5776CN).

Table 9. Activity Unit Acres in Alternative D That Overlap Steep Slopes (greater than 35% slope).

Activity Unit	Activity	Unit Acres	Steep Slope Acres
01A	Ground	39	10
01C	Ground	37	8
20	***Ground***	***26.5***	***7***
29	Ground	11	9
30	Ground	34.5	7
33A	Ground	6.3	5
34	Ground	11.5	8
34A	Ground	27.9	17
41	Ground	8.9	2
42	Ground	26	10
Total			**83 Steep Slope Acres**

There are 830 acres of skyline activities in alternative D which is 30 acres more than alternative A and 270 acres more than alternative B. Skyline units with the same acres and polygon footprint in alternative D have the same analysis as alternative A and D (Table 12). Skyline units 21A, 21B, 21C, and 40 which are not included in alternative A or B have the same analysis as the other cable units due to similar soil profiles and slopes. Total skyline unit overlap of very shallow and shallow soil is 40 of 830 acres total.

There are 2.6 miles of temporary road proposed for alternative D with 1.6 miles already existing on the road template. One mile of temporary road will be new. The mile of new temporary road will result in 1.8 acres of detrimental soil conditions. Skyline unit 18 has most of the existing temp road that will be reopened for use. Soils in skyline unit 18 are all greater than 20 inches deep with ashy surface textures. There is 0.43 miles of new temporary road planned for shallow soil areas. Placement of the 0.43 miles will result in 0.8 acres of perpetual soil compaction into the foreseeable future. The remaining 0.57 miles of new temporary road can be obliterated to restore soil structure and hydrologic function. If the road is not obliterated it will also perpetually add to soil compaction percent of the project area.

All helicopter logging units in alternative D with the same acres and polygon footprint as alternative A and B have the same analysis and effects (Table 13). Alternative D has 75 acres of identified helicopter activity which is 95 acres less than alternative A and 315 acres less than alternative B. Treatments and impacts of helicopter activities in alternative D are the same as discussed in alternatives A and B.

Indirect impacts of harvest activities by opening the tree canopy for increased understory growth include

increased soil nutrient cycling, soil hydrologic function, and soil productivity by limiting changes in soil temperature. As understory increases so does root turn over by grasses and forbs. Deciduous trees also increase and drop leaves yearly on the forest floor. The incorporation of dead roots and surficial litter into the upper horizons of the soil profile increases soil nutrients and hydrologic function. Decomposed organic matter acts as a sponge holding moisture. It also acts as a blanket to minimize the temperature of the upper soil profile. Decomposing organic matter also provides nutrients to establish grasses, forbs, shrubs, and trees. Increasing plant diversity by opening the forest canopy also increases the rate of soil recovery from soil compaction, displacement, and erosion. Exposing detrimental soil conditions to a variety of plant species allows for a variety of ways roots can break apart soil compaction and hold exposed sub-soil in place. Indirect effects to timber harvest are negligible to minor short term and can be positive in the long term when PDCs for varying specialties are followed.

Alternative D has six more cable activity units than alternative B which results in more acres of moderate soil displacement and compaction by vehicle activity and dragging of logs. Alternative D has the lease amount of helicopter units which means it has the greatest potential for soil disturbance by ground-based and skyline activities. Alternative D has two ground activity units that are helicopter units in alternative B with approximately 39 acres more soil displacement and compaction potential by vehicle activity and dragging of logs. Alternative D has 1 mile more temporary road than alternative B and associated 1.8 more acres of detrimental soil conditions. Alternative D has 0.05 miles less new temporary road proposed and associated 0.2 acres less of detrimental soil conditions when compared to alternative A. There are 15 more acres of shallow soil/ground-based overlap in alternative D when compared to alternatives A and B.

CUMULATIVE IMPACTS ANALYSES:

Cumulative effects for alternative D are like alternative A, but with 150 acres more ground activity from skyline and ground-based logging. Soil productivity can be negatively affected by as much as 12 percent in this alternative compared to alternative A and as much as 30 percent compared to alternative B. There are 16 fewer acres of shallow soil/ground disturbance overlap in alternative D when compared to alternatives A and B. Potential for persistent detrimental soil conditions is less with this alternative as result of the decreased acres of ground-based activity on shallow soil.

The addition of 4.5 acres of temporary road will add 1.8 acres of new soil compaction and displacement to the project area as will alternative A. Obliteration of the new road will restore soil productivity to the 1.8 acres. Storage of the new road will add the 1.8 acres of detrimental soil conditions in multiple activity units of the project area. The addition of 1.8 acres detrimental soil conditions to the overall project is negligible and will not cause the project exceed 20 percent detrimental soil conditions as identified in the forest plan.

Potential for detrimental soil conditions is greater as result of the increased acres of ground-based activity on shallow soil in alternative D but with the application of PDCs the overall effect to soil productivity will be the same as the other two alternatives. Cumulative impacts of alternative D include the most ground-based and skyline soil disturbance than the other two alternatives and 1.8 acres of detrimental soil conditions by new temporary road placement. All other cumulative impacts would be the same as alternative A and B. Because there is no change in activity type proposed in alternative D the indirect impacts are the same as alternative A and B.

CONCLUSION:

Overall impacts by ground-based activities are negligible to minor short term adverse direct impacts occurring on the project site when recommendations and PDCs are followed. Overall impacts are negligible to minor short-term adverse impacts directly on the project site. Indirect impacts are potentially the same with the same severity. Because there is no change in activity type proposed in alternative D the indirect impacts are the same as alternative A and B.

Alternative D has 300 ground-based activity acres, 830 cable logging acres, and 75 helicopter acres. Because

alternative D overlaps alternative A conclusions would be the same for activities in alternative D except there would be 120 more acres of ground-based soil disturbance activity, approximately 30 more acres of skyline logging activity, and 95 fewer acres of helicopter logging activity.

Approximately 1.8 acres of detrimental soil conditions will be added to the project by the addition of 1 mile of new temporary roads. Overall impacts by ground-based activities are negligible to minor short term adverse direct impacts occurring on the project site when recommendations and PDCs are followed. Overall impacts are negligible to minor short-term adverse impacts directly on the project site. Indirect impacts are potentially the same with the same severity.

Potential for soil compaction and displacement by skyline and ground-based activities on very shallow and shallow soil is the same for alternatives A and B with 63.5 acres or 5 percent of the total project area and is greater in alternative D with 83 acres or 7 percent. These percentages identify the possible acres if all of them are disturbed. If normal harvest activity were performed in very shallow and shallow areas identified it estimated that soil compaction and displacement would only occur for less than half of the area, or 2 percent in alternatives A and B and 3 percent in alternative D. Avoiding very shallow soils within activity units can be achieved during administration of the sale by following the 'Lithic Soil and Managing Operations Guide' provided to sale administrators and shared with purchasers.

Ground-based activities on areas with steep slope (slope greater than 35%) is outside normal operating procedures and requires approval by a soil scientist or hydrologist as indicated by the forest plan. Where ground-based activities are planned soil displacement and compaction is anticipated for approximately 34 acres or 3 percent of the total project area for alternative A, 41 acres or 4 percent of alternative B, and 83 acres or 7 percent for alternative D. As with detrimental soil conditions associated with very shallow and shallow soils, not all the acres would be affected for the designated area if harvest activities were to occur. Thus, estimates of soil displacement and compaction would be about half or 2 percent for alternatives A and B and 3 percent for alternative D. Avoiding steep slope areas is recommended. Where ground activities are planned, following PDCs 9 and 17 will lessen the effects to soil productivity.

Table 10. Alternative Activity Units and Acres

Alt A Unit	Alt A Acres	Alt A Activity	Alt B Unit	Alt B Acres	Alt B Activity	Alt D Unit	Alt D Acres	Alt D Activity
01A	38.9	Ground	01A	38.9	Ground	01A	38.9	Ground
01B	14.7	Ground	01B	14.7	Ground	01B	14.7	Ground
01C	37	Ground	01C	37	Ground	01C	37	Ground
2	17.4	Ground	2	17.4	Ground	2	17.4	Ground
3	20.9	Cable	3	20.9	Cable	3	20.9	Cable
4	6.5	Cable	4	6.5	Cable	4	6.5	Cable
5	9.3	Helicopter	5	9.3	Helicopter	***5***	***13.5***	***Helicopter***
10	27.9	Cable	10	27.9	Cable	10	27.9	Cable
11	13.1	Ground	11	13.1	Ground	11	13.1	Ground
12	8.6	Cable	12	8.6	Helicopter	12	8.6	Cable
12A	39.9	Cable	12A	39.9	Helicopter	12A	39.9	Cable
12B	15.9	Helicopter	12B	15.9	Helicopter	12B	15.9	Helicopter
12C	29.9	Helicopter	12C	29.9	Helicopter	12C	29.9	Helicopter
13	9.3	Cable	13	9.3	Cable	13	9.3	Cable
14	19.8	Cable	***14***	***10.5***	***Cable***	14	19.8	Cable

			14A	9.3	Helicopter			
17	85.6	Cable	17	85.6	Cable	***17***	***90.3***	***Cable***
18	9.7	Cable	18	9.7	Cable	***18***	***79.5***	***Cable***
18A	62	Helicopter	18A	62	Helicopter			
19	39.2	Helicopter	19	39.2	Helicopter			
20	26.5	Cable	20	26.5	Ground	20	26.5	Ground
21	8.8	Cable	21	8.8	Cable	21	8.8	Cable
						21A	16.1	Cable
						21B	14.1	Cable
						21C	4.6	Cable
22	35.2	Cable	22	35.2	Cable	22	35.2	Cable
23	65.8	Cable	23	65.8	Cable	23	65.8	Cable
24	33.2	Cable	24	33.2	Cable			
24A	11.3	Cable	24A	11.3	Cable			
25	76.2	Cable	25	76.2	Cable	25	76.2	Cable
25B	15.6	Helicopter	25B	15.6	Helicopter	25B	15.6	Helicopter
26	103.5	Cable	***26***	***88.9***	***Cable***	26	103.5	Cable
			26A	14.6	Helicopter			
28	23.8	Cable	28	23.8	Helicopter	28	23.8	Cable
28A	10.5	Ground	28A	10.5	Ground	28A	19.3	Ground
29	11	Ground	29	11	Ground	29	11	Ground
30	34.5	Ground	30	34.5	Ground	***30***	***42.4***	***Ground***
31	7.3	Cable	31	7.3	Cable	31	7.3	Cable
32	8.3	Cable	32	8.3	Helicopter	32	8.3	Cable
33	54.7	Cable	33	54.7	Helicopter	***33***	***48.4***	***Cable***
						33A	6.3	Ground
34	11.5	Cable	34	11.5	Helicopter	34	11.5	Ground
34A	22.6	Cable	34A	22.6	Helicopter	34A	27.9	Ground
35A	24.8	Cable	35A	24.8	Helicopter	35A	24.8	Cable
36	5.2	Cable	36	5.2	Cable	36	5.2	Cable
38	22	Cable	38	27.8	Cable	38	27.8	Cable
39	31.5	Cable	39	25.7	Cable	39	25.7	Cable
						40	32.9	Cable
						41	8.9	Ground
						42	26	Ground
41 units	1150	**Total**	43 units	1150	**Total**	44 units	1205	**Total**
8 units	180	Ground	9 units	200	Ground	14 units	300	Ground
27 units	800	Cable	18 units	560	Cable	26 units	830	Cable
6 Units	170	Helicopter	16 units	390	Helicopter	4 units	75	Helicopter

Table 11 – Alternatives and Ground-Based Units with Acres

Alt A Unit	Alt A Acres	Alt A Activity	Alt B Unit	Alt B Acres	Alt B Activity	Alt D Unit	Alt D Acres	Alt D Activity
01A	38.9	Ground	01A	38.9	Ground	01A	38.9	Ground
01B	14.7	Ground	01B	14.7	Ground	01B	14.7	Ground

01C	37	Ground	01C	37	Ground	01C	37	Ground
2	17.4	Ground	2	17.4	Ground	2	17.4	Ground
11	13.1	Ground	11	13.1	Ground	11	13.1	Ground
20	26.5	Cable	20	26.5	Ground	20	26.5	Ground
28A	10.5	Ground	28A	10.5	Ground	28A	19.3	Ground
29	11	Ground	29	11	Ground	29	11	Ground
30	34.5	Ground	30	34.5	Ground	***30***	***42.4***	***Ground***
						33A	6.3	Ground
34	11.5	Cable	34	11.5	Helicopter	34	11.5	Ground
34A	22.6	Cable	34A	22.6	Helicopter	34A	27.9	Ground
						41	8.9	Ground
						42	26	Ground
8 units	**180**	**Ground**	**9 units**	**200**	**Ground**	**14 units**	**300**	**Ground**
41 units	1150	**Total**	43 units	1150	**Total**	44 units	1205	**Total**

Table 12 – Alternatives and Cable (Skyline) Units with Acres

Alt A Unit	Alt A Acres	Alt A Activity	Alt B Unit	Alt B Acres	Alt B Activity	Alt D Unit	Alt D Acres	Alt D Activity
3	20.9	Cable	3	20.9	Cable	3	20.9	Cable
4	6.5	Cable	4	6.5	Cable	4	6.5	Cable
10	27.9	Cable	10	27.9	Cable	10	27.9	Cable
12	8.6	Cable	12	8.6	Helicopter	12	8.6	Cable
12A	39.9	Cable	12A	39.9	Helicopter	12A	39.9	Cable
13	9.3	Cable	13	9.3	Cable	13	9.3	Cable
14	19.8	Cable	***14***	***10.5***	***Cable***	14	19.8	Cable
17	85.6	Cable	17	85.6	Cable	***17***	***90.3***	***Cable***
18	9.7	Cable	18	9.7	Cable	***18***	***79.5***	***Cable***
20	26.5	Cable	20	26.5	Ground	20	26.5	Ground
21	8.8	Cable	21	8.8	Cable	21	8.8	Cable
						21A	16.1	Cable
						21B	14.1	Cable
						21C	4.6	Cable
22	35.2	Cable	22	35.2	Cable	22	35.2	Cable
23	65.8	Cable	23	65.8	Cable	23	65.8	Cable
24	33.2	Cable	24	33.2	Cable			
24A	11.3	Cable	24A	11.3	Cable			
25	76.2	Cable	25	76.2	Cable	25	76.2	Cable
26	103.5	Cable	***26***	***88.9***	***Cable***	26	103.5	Cable
28	23.8	Cable	28	23.8	Helicopter	28	23.8	Cable
31	7.3	Cable	31	7.3	Cable	31	7.3	Cable
32	8.3	Cable	32	8.3	Helicopter	32	8.3	Cable
33	54.7	Cable	33	54.7	Helicopter	***33***	***48.4***	***Cable***
34	11.5	Cable	34	11.5	Helicopter	34	11.5	Ground
34A	22.6	Cable	34A	22.6	Helicopter	34A	27.9	Ground
35A	24.8	Cable	35A	24.8	Helicopter	35A	24.8	Cable

36	5.2	Cable	36	5.2	Cable	36	5.2	Cable
38	22	Cable	38	27.8	Cable	38	27.8	Cable
39	31.5	Cable	39	25.7	Cable	39	25.7	Cable
						40	32.9	Cable
27 units	800	Cable	18 units	560	Cable	26 units	830	Cable
41 units	1150	**Total**	43 units	1150	**Total**	44 units	1205	**Total**

Table 13. Alternatives and Helicopter Units with Acres.

Alt A Unit	Alt A Acres	Alt A Activity	Alt B Unit	Alt B Acres	Alt B Activity	Alt D Unit	Alt D Acres	Alt D Activity
5	9.3	Helicopter	5	9.3	Helicopter	***5***	***13.5***	***Helicopter***
12	8.6	Cable	12	8.6	Helicopter	12	8.6	Cable
12A	39.9	Cable	12A	39.9	Helicopter	12A	39.9	Cable
12B	15.9	Helicopter	12B	15.9	Helicopter	12B	15.9	Helicopter
12C	29.9	Helicopter	12C	29.9	Helicopter	12C	29.9	Helicopter
			14A	9.3	Helicopter			
18A	62	Helicopter	18A	62	Helicopter			
19	39.2	Helicopter	19	39.2	Helicopter			
25B	15.6	Helicopter	25B	15.6	Helicopter	25B	15.6	Helicopter
			26A	14.6	Helicopter			
28	23.8	Cable	28	23.8	Helicopter	28	23.8	Cable
32	8.3	Cable	32	8.3	Helicopter	32	8.3	Cable
33	54.7	Cable	33	54.7	Helicopter	***33***	***48.4***	***Cable***
						33A	6.3	Ground
34	11.5	Cable	34	11.5	Helicopter	34	11.5	Ground
34A	22.6	Cable	34A	22.6	Helicopter	34A	27.9	Ground
35A	24.8	Cable	35A	24.8	Helicopter	35A	24.8	Cable
6 Units	170	Helicopter	16 units	390	Helicopter	4 units	75	Helicopter
41 units	1150	**Total**	43 units	1150	**Total**	44 units	1205	**Total**